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Automotive Exhaust Analysis for a New Engine Oil Additive

A Final Report to
Genirev, Inc.
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THE AIR QUALITY LABORATORY

Introduction

Genirev, Inc. (Nashville, TN) requested that the Georgia Institute of Technology Air Quality Laboratory (AQL) conduct emission testing to evaluate the effectiveness of an engine oil additive at reducing vehicle emissions and improving vehicle fuel economy. All vehicle testing was conducted at the AQL dynamometer facility in Riverdale, Georgia under controlled conditions. Mileage accumulation was conducted onroad by representatives of Genirev under the supervision of AQL employees. The gasoline used for the study was in-use unleaded fuel supplied by AQL. Five vehicles were selected by Genirev for the testing program. These vehicles widely varied in age, mileage and engine class.

Equipment

All vehicle testing was conducted at the AQL chassis dynamometer laboratory in Riverdale, Georgia. Test procedures are run on a Clayton 8 5/8" dual roll, hydrokinetic chassis dynamometer. During the test procedures vehicle emissions are collected with a constant volume sampler, CVS (CVS-20, Horiba Instruments, Inc., Irvine, CA). The CVS dilutes a portion of the tailpipe exhaust with ambient air that has been filtered and then delivers a constant volume of this mixture to a Teflon bag for subsequent chemical analysis. In addition to the dilute exhaust sample, the CVS also collects a sample of the ambient background emissions for comparison.

After the vehicles have been run on the dynamometer, the bag samples are analyzed with a dilute bag bench, (Series 200, Horiba Instruments, Inc.). The bench contains instruments for the analysis of carbon dioxide (CO_2), carbon monoxide (CO), total hydrocarbons (THC), Methane (CH_4), and nitrogen oxides (NO_x). Both CO and CO_2 are measured by non-dispersive infrared (NDIR) instruments. A flame-ionization detector (FID) is used for THC and CH4. Nitrogen oxides are measured via ozone-chemiluminescence. All the instruments are calibrated by dynamic-dilution of NIST-traceable primary standards over the range of interest.

All emission and dynamometer testing are conducted in accordance with manufacturers and EPA specifications. Dynamometer coast-downs are conducted for each vehicle weight setting and the CVS flow is verified by propane injections with a critical flow orifice.

Vehicles

Five vehicles of widely varying age, mileage and engine class were selected by Genirev for this testing program. Table 1 provides a summary of these five vehicles listed by model year. Included in Table 1 are the dynamometer settings for inertial weight and indicated horsepower. Photos of each vehicle during testing are provided in Appendix A.

Table 1. Vehicle Specifications						
Make	Model	Year	Mileage	Engine	Inertial Wt	iHp
Chevy	Van 20	1992	119693	4.3L	5250	11.1
Chevy	Beretta	1995	66850	3.1L	3375	4.0
Ford	Thunderbird	1997	56753	3.8L	3875	6.8
Dodge	Stratus	2000	8223	2.4L	3375	3.9
Dodge	Ram1500	2001	4366	5.2L	5500	10.9

Experimental Protocol

Each vehicle was inspected upon reception at the laboratory. Prior to baseline testing, each vehicle had the oil changed and a new oil filter installed. The same type of oil was used in each vehicle. In addition, the vehicles were drained of fuel and the in-use test fuel (Chevron Unleaded, 87 octane) was added.

Two baseline test procedures were run on each vehicle. The First test procedure used was the U.S. EPA Federal Test Procedure (FTP-75) based on the urban dynamometer driving schedule (UDDS). After the vehicles have been prepped they are allowed to soak for at least 12 hours at a constant temperature before the test is conducted. The FTP consists of a cold start UDDS, a 10-minute soak and then a hot start repeat of the first 505 seconds (hills 1-5) of the UDDS. The drive cycle of the FTP is shown in Figure 1. During the FTP, dilute exhaust emissions are collected in three separate bags. Bag 1 is the cold transient drive and consists of the first 505 seconds. Bag 2 is the Cold stabilized drive and consists of the next 866 seconds. No exhaust sample is collected during the 10 minute soak period. Bag 3 is the hot transient drive (also known as the hot-505) and is the last 505 seconds of the test.

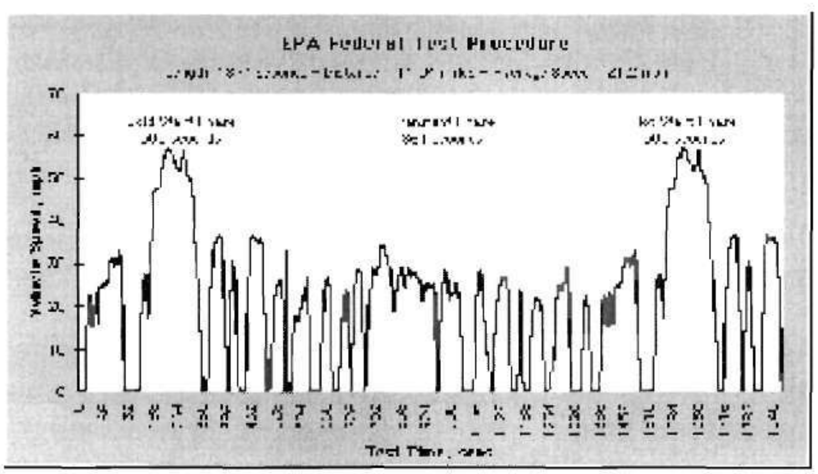

Figure 1. The Federal Test Procedure

The second test procedure that was run on each vehicle was the Highway Fuel Economy Cycle (HWFEC). The HWFEC test is run twice, the first test is to warm-up and stabilize the vehicle and the second test is to measure the emissions for the fuel economy calculations. The HWFEC is 765 seconds in length and the drive cycle is shown in Figure 2.

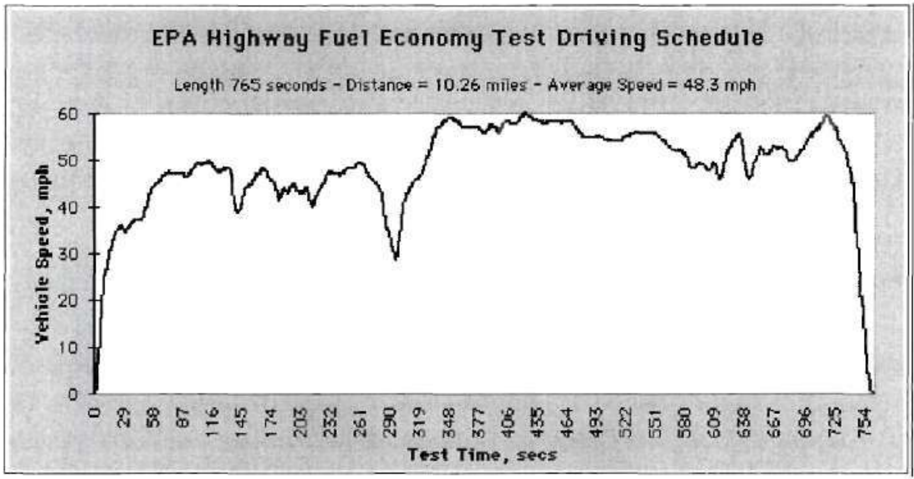

Figure 2. The Highway Fuel Economy Test Procedure

After each vehicle had been run on the FTP and HWFEC cycles, the oil was drained and the oil filter was changed. The same type of oil was added and this time the new oil additive was added. The vehicles were then driven approximately 850 miles over the next two days under the supervison of an AQL employee. No modifications were made to the vehicles during the mileage accumulation stage. All vehicles were refueled together using regular, 87 octane unleaded gasoline. A mileage summary for each vehicle is provided in Table 2.

Table 2. Mileage Accumulation Statistics

Vehicle	Starting Mileage	Ending Mileage	Mileage Accumulation
Van	119738.4	120594.6	856
Beretta	66884.1	67776.3	892
Thunderbird	56785	57632	847
Stratus	8270	9123	853
Ram	4388	5242	854

At the completion of the mileage accumulation stage, each vehicle again had an oil and oil filter change. The fuel was drained from each vehicle and the same test fuel was added and each vehicle was allowed to soak for the required 12 hours.

After the soak period, each vehicle was tested according to the FTP and then run on the HWFEC test. The exhaust emissions were analyzed and then compared with the baseline tests.

Results
Emissions

During the FTP, three bags of diluted exhaust gas are collected for each vehicle and then analyzed for CO, CO_2, NO_x, THC and CH_4. The exhaust emissions are first measured on a volume basis and are then these numbers are converted to mass basis (grams/mile) based on the distance the vehicle traveled during the test. The final emission numbers are then weighted for the cold and the hot emissions relative to actual driving conditions. The emissions from Bags 1 and 2 are summed and then weighted by 43% and the emissions from Bags 2 and 3 are summed and weighted by 57%.

All five vehicles showed a reduction in CO and THC and three of the five vehicles showed a reduction in NOx from the baseline numbers. All of the weighted emission results are shown in Table 3. Figure 3 graphically shows the CO reductions for each vehicle. Reductions ranged from almost 32% for the Dodge Stratus to about 3% for the Dodge Ram. CO emission reductions for the sum of all vehicles was 19.9% (from a sum of 10.6 g/mile to 8.5 g/mile).

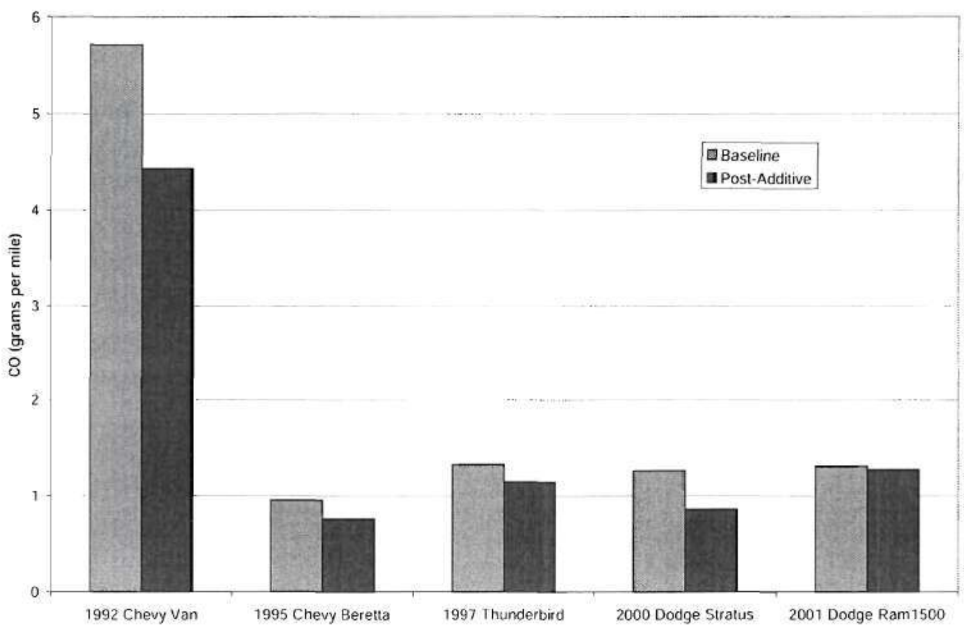

Figure 3. Comparison of Baseline and Post-Additive Emissions for CO

Total Hydrocarbon emissions were also reduced for each vehicle in the study. Reductions ranged from 16.1% for the Chevy Beretta to almost 53% for the Ford Thunderbird. The summed reduction for hydrocarbons was 26.8%. Figure 4 shows the total hydrocarbon reductions for each vehicle.

Results for nitrogen oxide emissions varied between all the vehicles with three of the vehicles showing some improvements in emissions. The Dodge Ram had a 42.7% improvement while the Chevy Van had a 31% increase in NO_X emissions. There was no summed change in NO_X emissions, 1.8 g/mile baseline to 1.8 g/mile after. Nitrogen oxide emissions for each vehicle is shown in Figure 5.

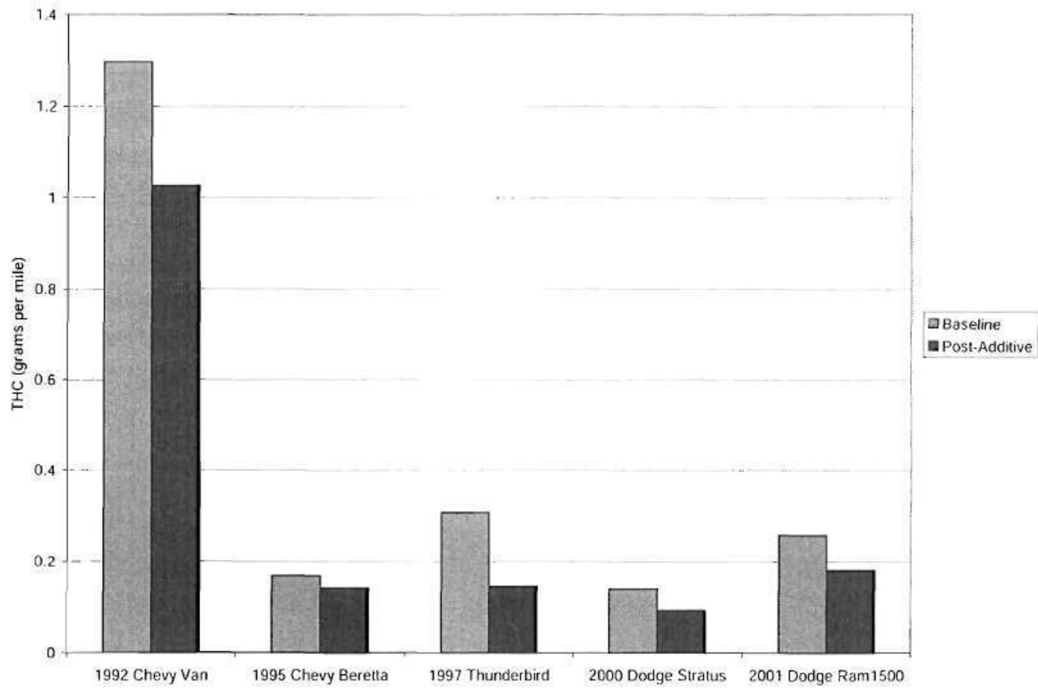

Figure 4. Comparison of Baseline and Post-Additive Emissions for THC

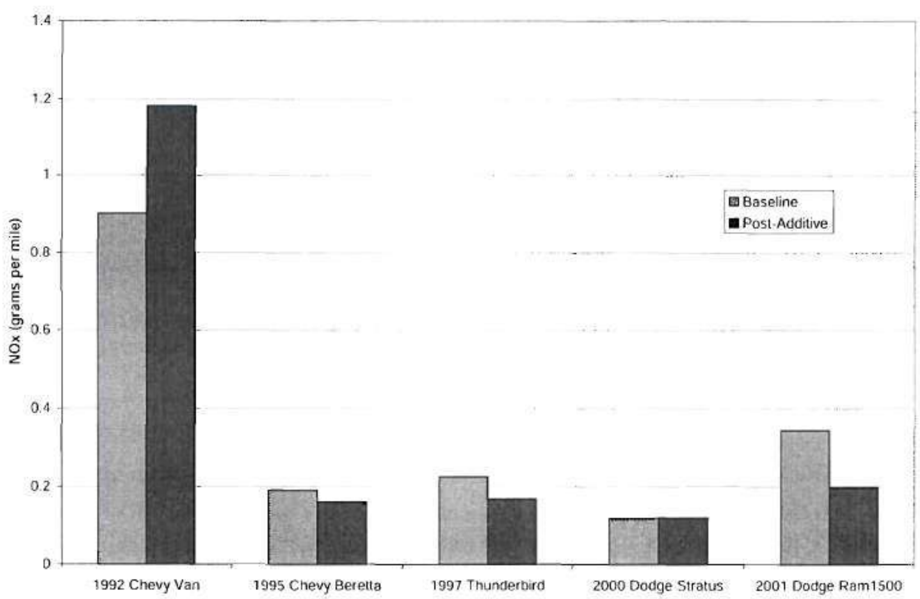

Figure 5. Comparison of Baseline and Post-Additive Emissions for NO_X

Table 3. Vehicle Emissions from the FTP (grams/mile)

1992 Chevy Van

	CO	CO2	NOx	THC	CH4
Baseline	5.717	449.7	0.901	1.297	0.102
Post Additive	4.435	419.6	1.18	1.027	0.069
Percent Change	-22.4%	-6.7%	31.0%	-20.8%	-32.4%

1995 Chevy Beretta

	CO	CO2	NOx	THC	CH4
Baseline	0.957	395.4	0.191	0.168	0.011
Post Additive	0.762	400.1	0.161	0.141	0.009
Percent Change	-20.4%	1.2%	-15.7%	-16.1%	-18.2%

1997 Thunderbird

	CO	CO2	NOx	THC	CH4
Baseline	1.33	410.3	0.225	0.307	0.037
Post Additive	1.146	404.2	0.169	0.145	0.02
Percent Change	-13.8%	-1.5%	-24.9%	-52.8%	-45.9%

2000 Dodge Stratus

	CO	CO2	NOx	THC	CH4
Baseline	1.261	395.6	0.119	0.139	0.024
Post Additive	0.859	393.3	0.12	0.093	0.015
Percent Change	-31.9%	-0.6%	0.8%	-33.1%	-37.5%

2001 Dodge Ram1500

	CO	CO2	NOx	THC	CH4
Baseline	1.309	698.9	0.344	0.257	0.045
Post Additive	1.273	620.5	0.197	0.181	0.031
Percent Change	-2.8%	-11.2%	-42.7%	-29.6%	-31.1%

Fuel Economy

Fuel economy is divided into two categories, city and highway. The city fuel economy numbers are calculated based on the emission measurements of CO_2, CO and THC made during the FTP. The highway fuel economy numbers are calculated based on the emission measurements during the HWFEC. For labeling purposes and to correlate more with actual in-use driving patterns, the city fuel economy is multiplied by 0.9 and the highway fuel economy is multiplied by 0.78.

The weighted city fuel economy numbers are presented in Table 4. All fuel economy values are in mile per gallon (MPG). Both of the V-8 engines that were in this study showed significant increase in fuel economy numbers. The Chevy Beretta was the only vehicle to show a decrease in city fuel economy. The weight highway fuel economy numbers are shown in Table 5.

Table 4. City Fuel Economy

	Baseline MPG	Additive MPG	Change
1992 Chevy Van	17.4	18.7	7.7%
1995 Chevy Beretta	20.2	20.0	-1.1%
1997 Thunderbird	19.4	19.8	1.7%
2000 Dodge Stratus	20.2	20.3	0.8%
2001 Dodge Ram1500	11.4	12.9	12.7%

Table 5. Highway Fuel Economy

	Baseline MPG	Additive MPG	Change
1992 Chevy Van	21.8	22.6	3.8%
1995 Chevy Beretta	29.5	29.2	-1.0%
1997 Thunderbird	27.6	26.7	-3.3%
2000 Dodge Stratus	29.3	29.2	-0.3%
2001 Dodge Ram1500	17.4	18.3	5.6%

The combined fuel economy numbers are calculated by weighting and harmonically averaging the city and highway fuel economy numbers.

$$MPG_{combined} = \frac{1}{\frac{0.55}{MPG_{city}} + \frac{0.45}{MPG_{hwy}}}.$$

The combined fuel economy results are shown in Table 6.

Table 6. Combined Fuel Economy

	Baseline MPG	Additive MPG	Change
1992 Chevy Van	19.1	20.3	6.1%
1995 Chevy Beretta	23.5	23.3	-1.0%
1997 Thunderbird	22.4	22.4	-0.2%
2000 Dodge Stratus	23.5	23.6	0.4%
2001 Dodge Ram1500	13.5	14.9	10.1%

Conclusions

Based on the data from this study, it can be concluded that the oil additive improves the carbon monoxide and total hydrocarbon emissions from vehicles. Emission improvements of 19.9% and 26.8% for CO and THC, respectively, were seen in this study. Based on the average reduction of 0.4 g/mile of CO per vehicle and if this reduction is carried for the life of the oil additive (Genirev claims the oil additive has a 40,000 mile life span) this represents a reduction of 16.8 kg of CO per vehicle.

Fuel economy improvements where less distinct with the exception of the larger V-8 engines which saw a significant enhancement in fuel economy. Averaged over the five vehicles, total fuel economy improvements were about 2.5%.

Ideally the oil additive should be allowed to work in the engine for one oil change cycle or between 3000 and 5000 miles. Because of time constraints the mileage accumulation stage was only about 850 miles. Fuel economy numbers could have improved if the full mileage accumulation stage was conducted.

Future research should be focused on vehicle emission deterioration factors. Based on this study it can not be determined what is the useful lifespan of the product. The next study should cover the lifetime of the vehicle or around 100,000 miles. In this type of study, FTP and HWFEC tests are conducted every 10,000 miles to study the deterioration in vehicle emissions. Also, this study only looked at the emissions of the vehicle and did not make any attempt to address the issues associated with benefits from reducing engine wear.

References

Environmental & Energy Planning, Chrysler Corporation, *Emission and Fuel Economy Regulations,* April 1998.

United States Environmental Protection Agency, Office of Transportation and Air Quality, http://www.epa.gov/oms/.

Appendix A.

Vehicle Photos

Figure A.1 1992 Chevy Van20

Figure A.2 1995 Chevy Beretta

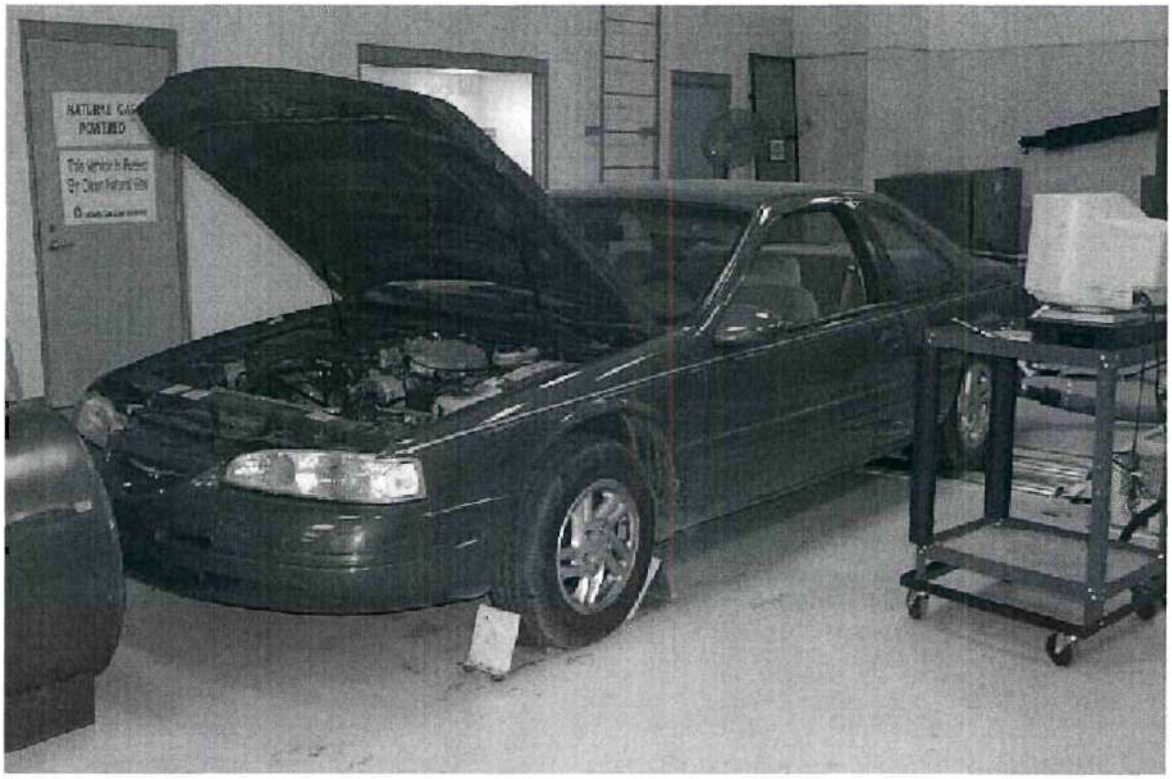

Figure A.3 1997 Ford Thunderbird

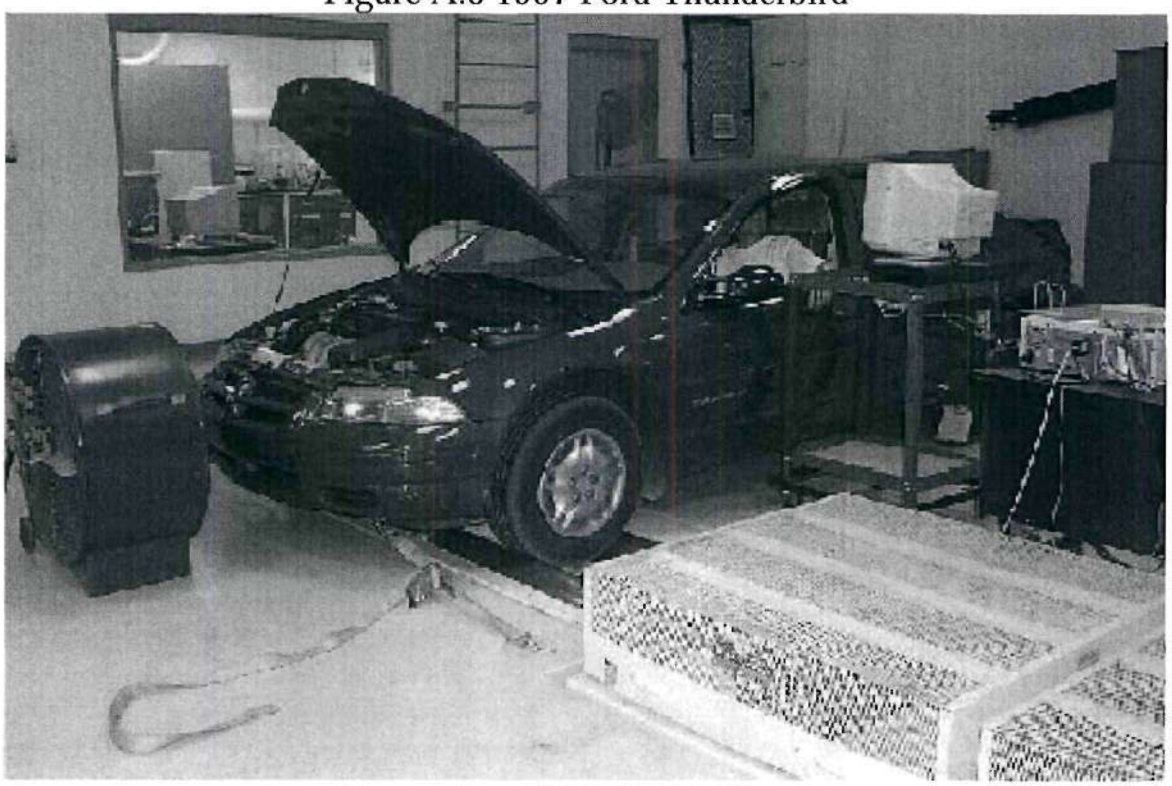

Figure A.4 2000 Dodge Stratus

Figure A.5 2001 Dodge Ram1500

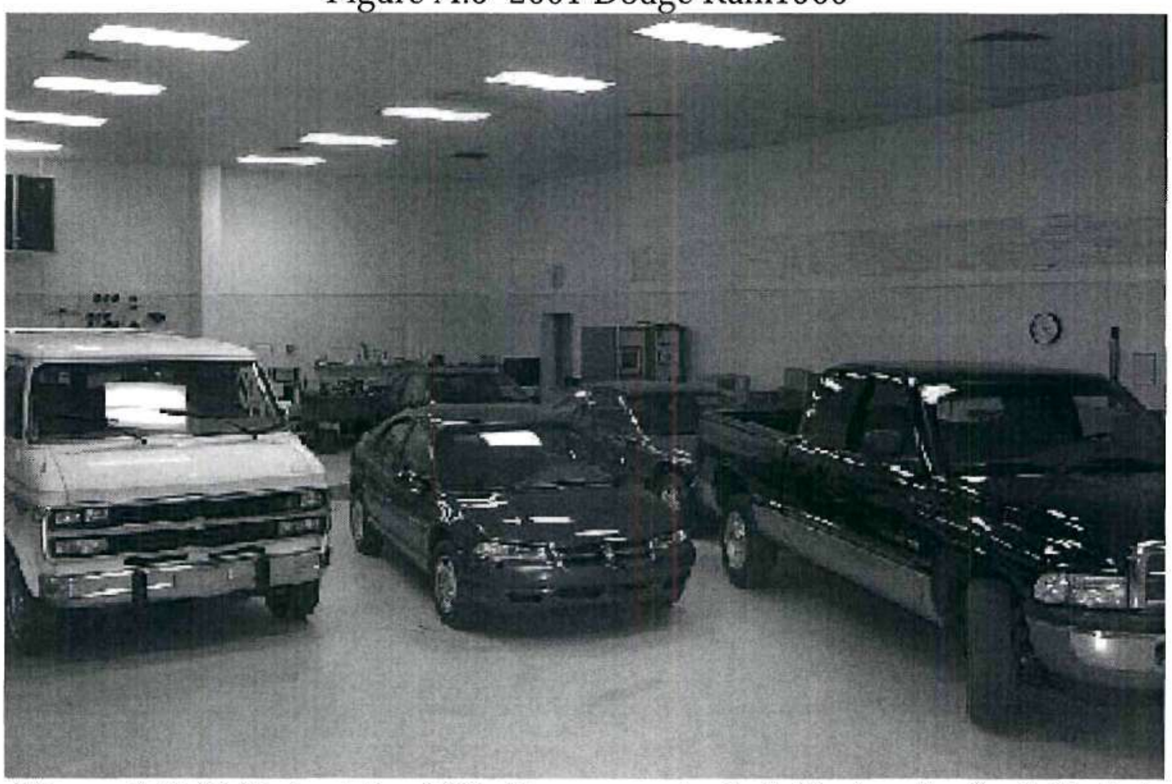

Figure A.6 Vehicle at the AQL Dynamometer Lab During the Soak Period